DOCUMENT RESUME

ED 475 943 IR 021 941

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TITLE Professional Development: Building Effective Virtual Communities through Cooperative Learning.

PUB DATE 2002-06-00

NOTE 21p.; In: NECC 2002: National Educational Computing Conference Proceedings (23rd, San Antonio, Texas, June 17-19, 2002); see IR 021 916.

AVAILABLE FROM For full text: http://confreg.uoregon.edu/necc2002/ .

PUB TYPE Reports - Evaluative (142) -- Speeches/Meeting Papers (150)

EDRS PRICE EDRS Price MF01/PC01 Plus Postage.

DESCRIPTORS *Computer Assisted Instruction; *Computer Mediated Communication; Constructivism (Learning); *Cooperative Learning; *Earth Science; Higher Education; Instructional Design; Middle School Teachers; *Professional Development; *Teacher Education; Teaching Methods

IDENTIFIERS *Virtual Communities

ABSTRACT

A web site for an online graduate course in Earth systems science for middle school teachers was designed to affect teachers' knowledge about Earth systems science and resources and their use of constructivist teaching practices, particularly collaboration, rubrics and the use of journals. In the 16-week course 44 teachers experienced collaborative inquiry as they worked in groups to develop knowledge of individual spheres and create Earth systems diagrams as teams. Individually, they created Earth systems science lessons and local event analyses. Teachers were administered an exploratory pre-course survey to guide ongoing development and formative assessment. A post-course survey provided information on the validity of the design and its affect on the participant's attitude changes; knowledge gains, time spent and suggestions for further improvement. An archive analysis is currently underway. Revisions to the site design and content, the course methodology and assessment tools are discussed. (Contains 26 references and 15 figures.) (Author)

Professional Development: Building Effective Virtual Communities through Cooperative Learning

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Abstract
A web site for an online graduate course in Earth systems science for middle school teachers was designed to affect teachers' knowledge about Earth systems science and resources and their use of constructivist teaching practices, particularly collaboration, rubrics and the use of journals. In the 16-week course 44 teachers experienced collaborative inquiry as they worked in groups to develop knowledge of individual spheres and create Earth systems diagrams as teams. Individually, they created Earth systems science lessons and local event analyses. Teachers were administered an exploratory pre course survey to guide ongoing development and formative assessment. A post course survey provided information on the validity of the design and its affect on the participant's attitude changes; knowledge gains, time spent and suggestions for further improvement. An archive analysis is currently underway. Revisions to the site design and content, the course methodology and assessment tools are discussed.

Introduction

Online courses consisting of communities of learners are experiencing increasing use and credibility (Duffy, Dueber and Hawley, in press; Hewitt and Scardamalia, 1997; Hewitt, Web and Rowley, 1994) due to their potential for increasing intentional learning through interpersonal interaction (Scardamalia and Bereiter, 1994). This paper outlines the design, development and implementation of an online middle school teachers' Earth systems science graduate course designed to use web-based interactions for learning. The themes of Earth system science (ESS) content and collaborative, inquiry-based science education mirror each other within an electronic environment where teacher participants take responsibility for their learning within a structure of clear expectations and a web of relationships.

Description of the course

This 16-week course was created to provide professional development in Earth system science for middle school teachers. The course was delivered through the World Wide Web (WWW) and used the jigsaw method of collaboration through threaded discussion areas. The course addressed the US National Research Council's standards for including inquiry-based approaches in science through explicitly modeling a collaborative, student-centered environment in which teachers relied on each other for input, knowledge-building and feedback.

Two sections of participants (middle-school teachers) enrolled in the course (N=44). Each section had two mentors, a master teacher and an Earth systems scientist. The role of the mentors was to answer Earth systems science questions, prime discussions, reply to journal entries, give feedback on Earth systems science thinking, connect course participants around interests and needs, provide administrative and technical assistance and track down people who did not post messages. Participants were chosen for the course based on access to the WWW and their stated interest in helping refine the course for future iterations.

Course activities consisted of online collaborative discussions to develop knowledge and exchange ideas, individual research for information concerning Earth systems science, team construction of Earth systems diagrams about major Earth events, and individual journal reflections.

Teacher Development: Building Effective Virtual Communities through Cooperative Learning
NASA ESSEA 5-8 Course

Inquiry in a Community of Learners

A primary concern during course design was to create an online learning environment of inquiry where interdependence among participants provided the glue necessary for a successful community of learners. To provide a framework for supporting inquiry, we looked to Bereiter's discussion of inquiry (1992) in which he describes the scientific approach to inquiry as the commitment to:

- work toward a common understanding satisfactory to all
- frame questions and propositions in terms of evidence
- expand the body of valid propositions
- subject any belief to examination

Davis's (1997) recipe for building a community includes shared goals, challenges that cause relationships to form through exchanges of ideas, regular reflection for metacognition, and a structure or place for the virtual community to form. One means of following this recipe is to have participants focus on information collection, then enter "virtual space" where they test ideas and ask questions of each other, and of mentors.

Rogers and Laws (1997) addressed the challenge of building an online community by supporting extensive discussions and providing opportunities for cooperative learning. Jigsaw cooperative learning structures (Grisham and Molinelli, 1995; Aronson, 1978) provide a useful method for creating interdependence by having team members form temporal ad hoc groups to become "experts" on a content area, then return to their original team to share their expertise. Cooperative learning like that required in the Jigsaw method requires interaction among students on learning tasks. The belief is that the interaction in itself will lead to students to construct knowledge (Damon, 1984; Murray, 1982; Wadsworth, 1984). "Students learn from one another because in their discussions of the content, cognitive conflicts arise, inadequate reasoning be exposed, disequilibrium will occur, and higher-quality understandings will emerge" (Slavin, 1995b).

Electronic Tools for Building a Community of Learners

Web design goals to support inquiry in an electronic distributed environment have been developed by Duffy, Dueber and Hawley (in press):

- focus the user on problem solving
- promote attention to and reflection on the argument and goals
- provide appropriate structures for the communication need
- support coaching

These design goals led to the construction of the ACT tool (Asynchronous Collaboration Tool) with two discussion spaces: conversational and issues-based. Using a PBL model, learners generate questions in conversational space (chronologically organized) and then develop full arguments in issue-based discussions (organized with topical threads.) The notion of different spaces for different functions defines the task and protocol for contribution, providing both focus and comfort to the participants to encourage participation.

Establishing intention and protocols for discussions is paramount in Scardamalia and Bereiter's (1991) CSILE (Computer Supported Intentional Learning Environment) system. Learners label their entries in the database in terms of thinking, such as "what I need to know" or "my theory" or "new experiment" (Oshima, 1994). Recent research (Hewitt, Web, and Rowley, 1994) suggests that considerable face-to-face interaction may be necessary to the successful use of CSILE for rigorous inquiry. The Collaboratory Notebook (CoVis, Edelson and O'Neill, 1994) represents another electronic distributed learning tool for collaborative inquiry in which students label their entries as "information" "commentary" "question" and "conjecture" etc. The labels are intended to scaffold the discussion, and

invite connections and feedback. It is possible that their use eliminates one level of interpretation for the reader, so that responses are more forthcoming, connected and useful.

The challenge of creating and sustaining knowledge-building conversations using technology in face-to-face situations has been addressed by Brown and Campione (1994). Different groups are established to build individual and collective expertise, groups reform to address specific tasks as they are identified. Technology serves as a tool for managing information, but more importantly for establishing a growing base of knowledge applied to a task or problem.

In considering the core of virtual learning, Mitchell, writes, in City of Bits (1997), "no matter how extensive a virtual environment or how it is presented, it has an underlying structure of places where you meet people and find things and links connecting those places. This is the organizing framework from which all else grows. In cyberspace, the hyperplan is the generator."

Goals

The challenge presented for the design team of the Earth system science course was to create a collaborative learning environment exclusively online. It required integrating the research on collaborative learning in face-to-face situations, online environments, and emerging web systems such as ACT.

Two questions guided the development team in creating the course and the mentor team in implementing it:

- How do we create a community of learners to address how to teach Earth systems science through inquiry?
- What structures and tools will support a collaborative online learning environment?

The design had to accommodate the belief that experiencing collaborative inquiry is essential to being an effective Earth systems science teacher, within the context of no face-to-face interaction - an exclusively web-based environment. The following design elements were deemed critical to collaboration and knowledge-building:

- Complex tasks
- Differentiated roles
- Designated spaces for specific activities
- Reflection by learners
- Feedback learner-to-learner, mentor-to-learner
- Expanding information sources
- Clearly defined criteria for success (rubrics)

Design

The development team consisted of instructional designers, Earth systems scientists, a graphics artist, a web master, and an expert in creating online collaborative environments. The design goals led to decisions about the methodology, site design and tool selection. Discussion of each goal provided perspective and generated possibilities that were woven into the final design.

Collaborative structures in an online environment

An online environment supports the development and maintenance of a learning community in some interesting ways. Commitment and involvement are intensified by the public nature of the text-based environment. Reflection is facilitated by the asynchronous threaded public discussions and an online private journal. Self-regulation comes through the feedback from other members in developing "expert packets" and preparing systems diagrams according to criteria. A collaborative inquiry method supports the flow of energy toward new levels of understanding as members "jigsaw" between expert groups and event teams. Content and resources are provided in the week-by-week course outline, and a resource space grows with participants' suggestions.

Five main areas of the site greet course participants on the home page (Figure 1):

- Course Description
- Overview of Activities and Grading
- Library of Ideas and Resources
- Students' Guide to the Virtual Learning Community
- Weekly Course Outline (pull down menu with 16 weeks)

The *Course Description* briefly summarizes the collaborative methodology, goals, expectations for participation, and provides "getting started" resources on Earth systems science, inquiry and other topics. This section is designed to provide a common understanding of the "operating procedures" of the course, so participants have a structure to begin with which requires participation and rigorous thinking.

The *Overview of Activities and Grading* is listed on the home page to make the criteria for success clear and accessible. It was hypothesized that objective criteria would scaffold student-to-student and mentor-to-student feedback and collaboration in discussions (Figure 2).

The *Library of Ideas and Resources* is the entryway to the knowledge-building discussion areas, the reflective journal spaces and the evolving resource guide. Seven archival spaces in the *Classroom* (Figure 3) were created for specific purposes:

Whole Class Discussion Space
- Course Space - a general, administrative area for discussion

Whole Class Collection Spaces
- Classroom Application Space - individually developed activities
- Local Event Space - individually developed ESS diagrams
- Resource Space - for collecting resources for all course activities

Small Group Discussion Spaces
- Sphere Space - knowledge-building by sphere groups
- Event Space - ESS diagrams for the four events by event teams

Individual Reflection Space - Private
- Journal Space - weekly reflections on content/process of learning

The design incorporates "issue" and "conversational" spaces as proposed by Duffy et al (in press). In The Great Good Place (1989), Ray Oldenburg writes about the need for "third" places in modern community where an informal public life can develop, the mood is playful and there are "regulars." Virtual environments make good third places because people can come and go, recording their thoughts asynchronously, but connecting them with other people's ideas through the threaded discussions.

The site also incorporates public and private spaces for different size groups. Public spaces create a sense of belonging to a community that has its own life. The Course Space is a kind of bulletin board where messages are posted for everyone to see, while Sphere Space and Event Spaces are for small group teams to be productive together. They are public, but since everyone belongs to a group which is task or issue driven, they may not take the time to go to the other groups to drop in, pick up on the conversation or "lurk" so they are semi-private functionally. Private spaces support ongoing reflection about learning. In this case the Journal Space is a continuous record of self-reflection on what and how each person is learning and a way to communicate with mentors.

The designation of different spaces also supports differentiated roles, since each space has a particular task associated with it. The rubrics provide the scaffolding for the kind of thinking which needs occur for knowledge-building.

The *Students' Guide to the Virtual Learning Community* was written to scaffold the social interaction so essential to collaboration. There are also strategies to support the individual success of participants. Tips are given on how to write messages that get responses and how to give constructive feedback. As participants build ideas and knowledge in the Sphere and Event Spaces, many different kinds of interactions will occur. Gerdau (1998) suggests that group members engaged in collaborative inquiry develop more of an appreciation of the value of the group over time, as they develop listening, clarifying and piggybacking skills. The mentors will also coach participants in supportive feedback language, such as summarizing ideas, quoting sources, suggesting ideas and asking questions.

The *Weekly Course Outline* provides activities, resources and information. The importance of a clearly stated, challenging and complex task is described by Cohen (1986, pp. 69-70), who states "if the task is challenging and interesting, and if students are sufficiently prepared for skills in group process, students will experience the process of group work itself as highly rewarding."

The complex task is provided by the very nature of the Earth systems science content. By viewing Earth as a system, in which the land, water, air and living things are interdependent and co-evolving, students learn each of the areas in the context of the others, as well as applied to familiar settings and events. Event teams are asked to create an Earth systems diagram supported by a description for each of four events.

The Earth systems scientists on the team posited that Earth's systems are most clearly seen when they are under stress during anomalies, such as hurricanes, tornadoes, and flooding. By focusing on events such as these, as well as human induced stresses, such as deforestation, learners are able to identify the relationships among the spheres in light of the event. Four events were identified for the course which stress Earth systems and can benefit from the use of NASA resources such as satellite imagery: volcanoes, sea ice, hurricanes and deforestation.

Resources

The online environment was viewed as a place for collaboration and knowledge building, rather than a repository for Earth systems content. With this principle in mind, participants were mailed necessary background reading materials, CD-ROMs, and other supporting materials. The weekly instructions incorporate those resources. An abundance of resources encourages both independence and interdependence. Participants can choose the resources to fit their style and interests and contribute

information and reflections from those sources as well as their own experience. Interdependence is encouraged because it is difficult for one person to use all the resources, and so a team might organize to "divide and conquer" the readings. With an abundance of resources, individuals are more likely to be providing new information or complementary information from a different source, making it more valuable to the group in developing their ideas.

Course Methodology

The three goals of the course are: Earth Systems thinking; Event analysis and Classroom Applications. The event analysis is a common goal of each team and leads to the formation of the jigsaw expert groups and is followed by the development of a classroom application. Being part of two groups invites multiple perspectives, interdependence in data gathering from individual expertise and expert groups, and negotiation in developing a rigorous analysis. The implications for course methodology are to:

- define the team task
- provide a model of an Earth systems science analysis of an event
- plan repeated experiences for teams to do Earth systems science analyses
- plan to provide feedback on analyses
- develop guidelines for evaluating Earth systems science diagrams (rubrics)

Method

A post course survey was completed by 29 of the participants -14 in the Wheeling section and 15 in the Idaho section. Participants were asked to reflect on the importance of various skills to effective Earth systems science teaching, changes in their knowledge, attitudes and practice as a result of the course, and the effectiveness of the elements of the design. Data is presented in graph form to show simple averages or relative average ratings. T-tests for paired samples were used to test for significant difference between means where it was appropriate. The p values are reported in the narrative. This self-report data will be reexamined in light of the results of a subsequent study of the archival discussions and products of the participants.

Results

Thinking about science from an integrated, coordinated and thematic perspective requires a shift from the traditional discipline-based approach, a "reform of thought." The "right" answers are those that have the most support by the members of the group, given the current knowledge base.

As learners construct the systems diagrams, they build on each other's thinking, challenge it and support it, depending on what knowledge they bring from their sphere groups AND the connections they make in the process of thinking about all the effects within the system. In constructing the systems diagram, participants can build off each other's ideas and make sense of the emerging patterns of meaning in response to the challenge.

Perhaps the best test of the efficacy of an experience is whether or not you would recommend it to your friends. 24 of the 29 people responding said definitely "yes" to the question, "Would you recommend this course to a friend?" for reasons like these:

> "An excellent way to learn earth science from a new perspective, improve your Internet capabilities, great materials, learn to use a new research tool (the web)."
>
> "I would tell my friends that I learned a lot. That when the group works well together, you learn so much more than working alone... that I got some really wonderful free materials, and leads to some cool web sites...that I met a group of new friends and resources for new ideas."
>
> "I learned more from this course than I have learned in a long time."

A few teachers who found the course disjointed or too time consuming offered an opposing opinion:

> "Although I learned a lot, the course takes way too much time. I spent far more time that I would for most 3 credit courses."

Many participants had good ideas for how to prepare their friends for taking a "cutting edge" course as one person called it, including: stay involved with your group; ask lots of questions; set aside time to do it at least three days a week for a couple of hours and more on the weekends; be prepared to love it and spend a lot of time exploring ideas and resources.

What were participants' expectations? Did the course meet them? The responses were fairly evenly divided between: 1) wanting to learn more about Earth systems science and how to teach it; 2) wanting to improve in using the internet or computer for learning and teaching; and 3) no expectations. Approximately 90% of the people who finished the course had their expectations fulfilled and more. The remainder felt they had not invested enough time, or they did not enjoy the emphasis on group interaction. The range is represented by the comments below:

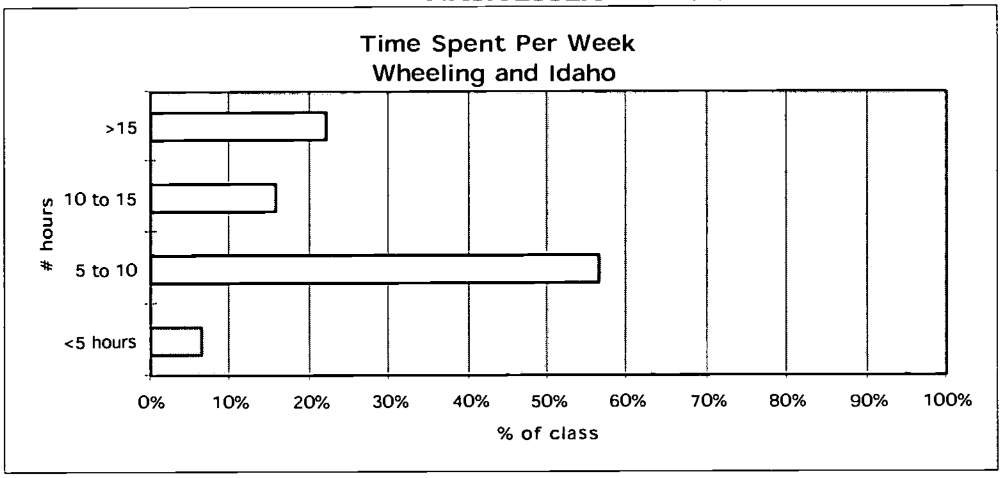
"That I would learn a new way of thinking about earth science concepts, and I would communicate via the web with other teachers around the state. I would also receive materials that I could use in my classroom. Class far surpassed my expectations."

"I guess I expected a more linear approach to the course and a clearer picture of what was required. I would have preferred to work on my own more."

Time Spent in the Course

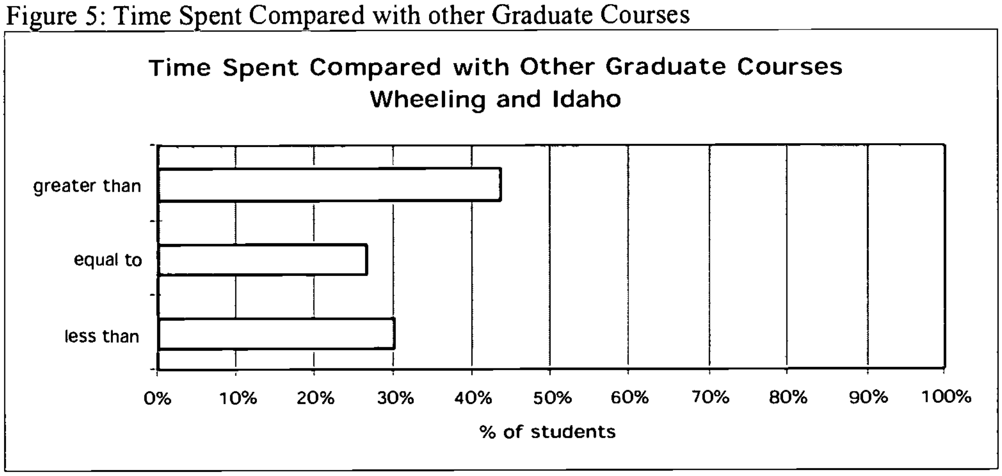
How much time did the participants spend in the course? Participants were asked how much time they spent per week in the course. The majority (94%) reported spending 5-10 hours per week or more due to depth and variety of resources (see Figure 4). Those who reported spending less than 5 hours per week (6%) most frequently commented that they could or should have spent more time, but did not have it available. Most people (56%) reported spending 5-10 hours a week.

Figure 4: Time Spent per Week



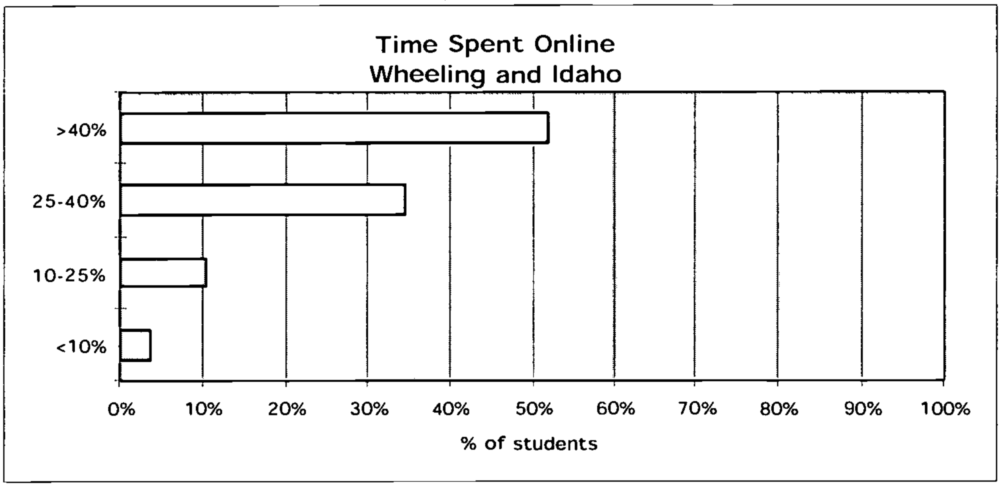
Relative to time spent on other graduate courses, 43% of the participants reported spending more time, 27% reported equal time, and 30% spent less time. For some participants, connectivity limited their time. See Figure 5.

Figure 5: Time Spent Compared with other Graduate Courses



How much time was spent online? 52% reported spending >40% of their time online using online resources and participating in the online discussions. See Figure 6.

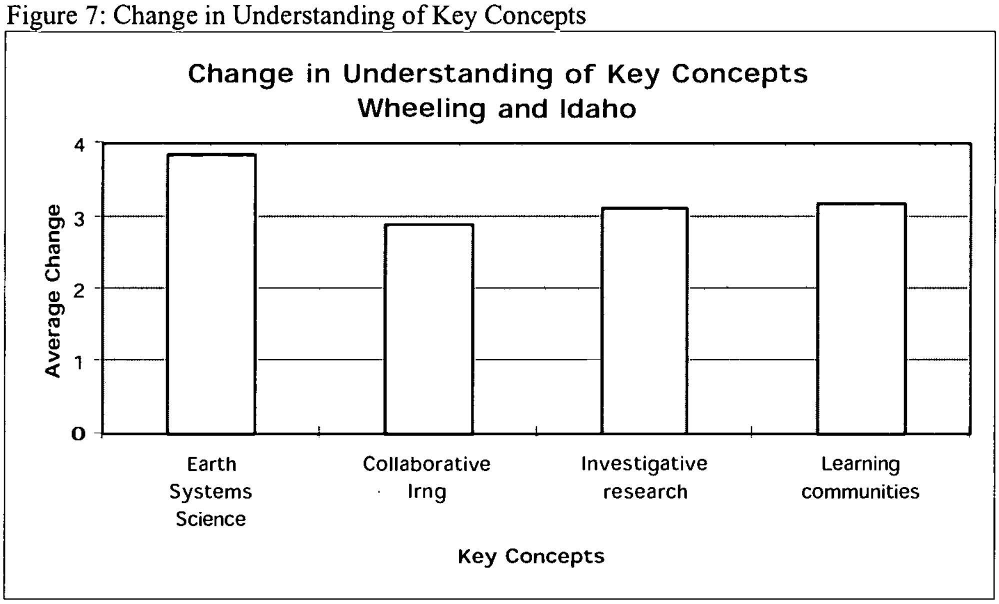
Figure 6: Time Spent Online



Change in understanding of key concepts

Participants were asked to rate the change in their understanding of Earth systems science, collaborative learning, investigative research and learning communities on a scale of 1 to 4 (highest). Average changes reported in Figure 7 indicate fairly substantial change. Participants reported the greatest change in their knowledge of Earth systems science (ratings ranged from 3-4). Several people reported a "rounding out" of their knowledge as a result of working in the sphere groups and having an opportunity to focus on one sphere at a time in relation to an event. Others reported that having to struggle with creating Earth systems diagrams for four different events showed them how much they had learned. Ratings for investigative research ranged from 2-4, and from 1-4 for collaborative learning and learning communities. Participants who rated no change in their understanding of collaborative learning also rated learning communities low (N=2) and commented on the lack of value in the group work.

Figure 7: Change in Understanding of Key Concepts



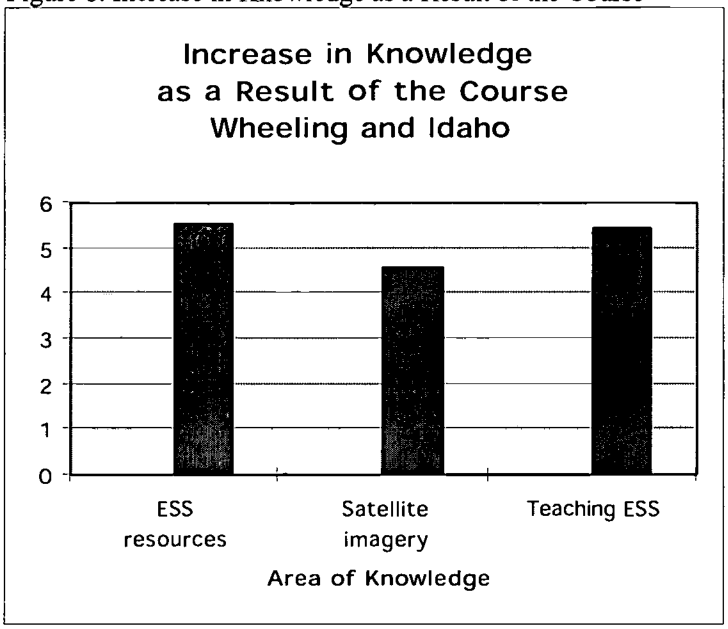
Increase in knowledge

A main goal of the course was to increase participants knowledge of Earth system science resources and teaching strategies, so they were asked to rate their change on a scale of 1-6 (highest). Comments

included: "I have binders full of great classroom activities and resources!" "It is absolutely amazing how many sites and resources are available. I am really excited about using these in my classroom next year."

Participants were also asked about the increase in their knowledge of satellite imagery since it was included in the course, but not extensively taught like it is in face-to-face sessions. The average rating for using satellite imagery was 4.58, lower than the other two areas. As expected, some participants felt they had only scratched the surface and wanted more in-depth instruction. Others had difficulty because of the slowness of a dial up connection. Others suggested more emphasis on this topic throughout the course.

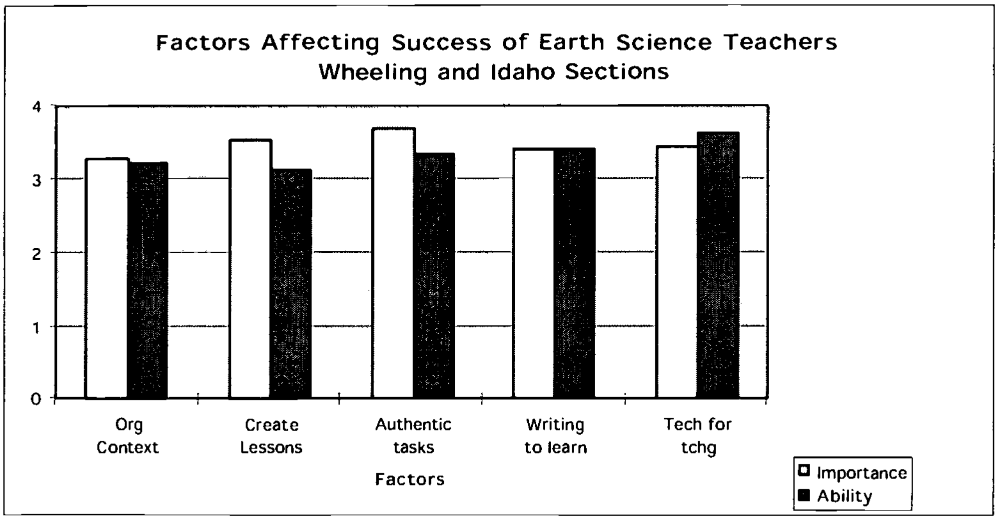
Figure 8: Increase in Knowledge as a Result of the Course



Factors Affecting Success of Earth Systems Science Teachers Participants were asked to rate the importance of five factors in the success of ESS teachers and then to rate their ability in each area as a result of the course (See Figure 9). On a scale of 1-4 (highest) all five factors had an average rating of 3 or better lending some support to the choice of these factors. Although the course did not directly address three of the five factors (organizational context, writing to learn, and using technology for teaching), it modeled them intensively.

When asked to rate their ability on the five factors as a result of the course, there was a significant difference (.05 level) between the importance and ability ratings in the areas of creating ESS lessons ($p=.005$) and authentic tasks ($p=.0226$), indicating participants still feel they need to improve in those areas relative to their perceived importance. No difference between importance and ability was found in the areas of organizational context ($p=.6253$) , writing to learn ($p=.8513$) and using technology for teaching ($p=.2266$) . This may indicate that there is adequate attention, support or learning in the course for these areas relative to their perceived importance. A separate analysis of the two sections of the course revealed no difference in importance and ability in the Wheeling section in creating ESS lessons ($p=.0454$), indicating greater comfort in this area for this section. A second study being conducted on archival transactions may shed some light on this difference between sections.

Figure 9: Factors affecting Earth systems science teachers



Participants were asked to respond to an open-ended question about their expectations for the course. Of the 33 participants who responded in the, 24 identified a key goal as gaining confidence and a better understanding in teaching ESS. Other goals included: improve in use of the Internet or technology (15); develop, locate lesson plans, activities and strategies I can use in my classroom/pedagogy (10). be made aware of ESS resources (5); and work/get to know others interested in ESS nationwide (5).

"I expected to learn about just the Earth's spheres. I didn't realize they would be connected to an event and they would affect each other during or after the event. My expectations were met many times over.

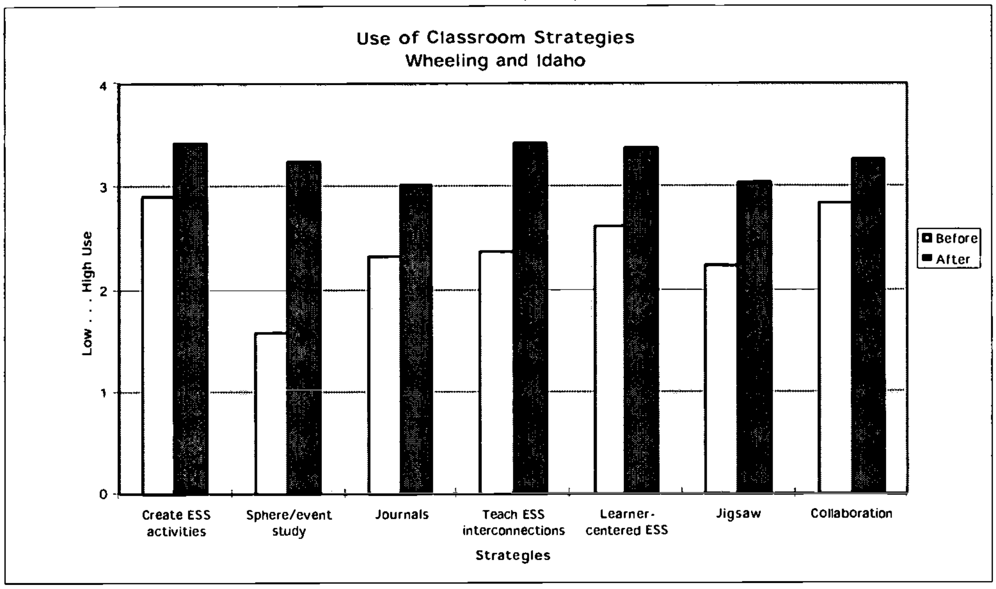
Use of Classroom Strategies

One of the goals of the course was to influence teachers to use strategies with their students that support learning Earth system science through immersing them in an environment that modeled those strategies. Criteria in the form of rubrics and sources of activities that use them were also provided.

Teachers were asked to rate their use of the strategies before and after course by responding to the question: "How likely were you to use this in your classroom prior to the course? After the course?" A significant difference (.05 level) was found in the entire sample for increased use of all the strategies associated with constructivism, including learner-centered activities ($p=.0032$), jigsaw ($p=.0064$), collaborative grouping ($p=.0002$), use of journals ($p=.0006$), teaching for connections ($p=.0001$), and sphere/event study groupings ($p=.0001$). Teachers reported greater intention to use all the strategies, especially the sphere/event strategy and teaching for Earth systems science interconnections.

As seen in Figure 10, teachers reported significant increases in the use of all strategies, especially in the area of sphere/event studies and in teaching for Earth systems science interconnections. This suggests an increased likelihood of use of these strategies as a result of the course. This is especially important, since few of the teachers reported using jigsaw learning groups before the course. One participant commented, "This course has provided a host of supportive contexts which I have internalized, enlarged upon, and will continue to expand upon."

Figure 10: Use of Classroom Strategies

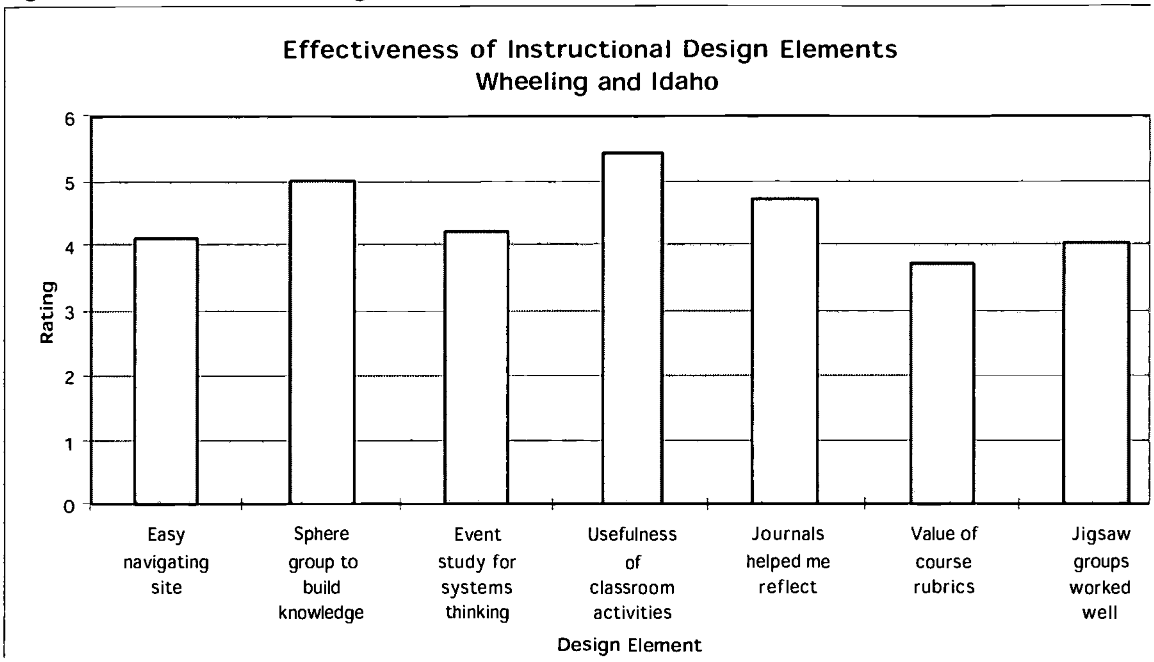


Effectiveness of Design

As discussed in the background section, the development of the web site environment for the course was guided by the design goals of particular spaces, functions, and flow to create a community of learners. Participants were asked to rate statements about the design elements from 1-6:

- I had no trouble navigating about the site itself. That is, material was presented in such a way that it was "obvious" as to how to make the "right choices."
- The sphere group exercises (jigsaw) helped the participants become knowledgeable in content area so that they could contribute to group discussions.
- The event study groups worked well for the participants. They helped in the development of the earth systems diagram.
- I plan to use the classroom activities I encountered during this course.
- The journals helped the participants reflect on what had taken place each week.
- The course rubrics were of great value.
- The jigsaw groups worked well for the participants.

Figure 11: Effectiveness of Design



As seen in Figure 11, average ratings ranged from 3.73 to 5.45, providing support for the effectiveness of the design elements in their desired roles. The rubrics were not posted in their final form until the third week, which may account for their lower rating. One participant commented, "The rubrics were great for guiding us on what exactly the course designers anticipated we would be doing in each space." Having specific expectations to meet increased the time commitment for some participants. One person commented, "It was just too time-consuming for me to put in the time to make the grade."

Participants almost universally appreciated the classroom activities and resources that pointed to them. The most popular ones included the volcano sites, Weather on other Planets, and the ETE modules, but the most frequent comment was, "so many were excellent."

The site design was fairly highly rated (4.15) for ease of navigation. Participants suggested embedding more directions in the weekly outline, making separate archives for the groups to work in, making the threads easier to read and browse, and checking in with every person within the first three days by phone, fax, or email) to make sure they are connected and have found all the parts of the site.

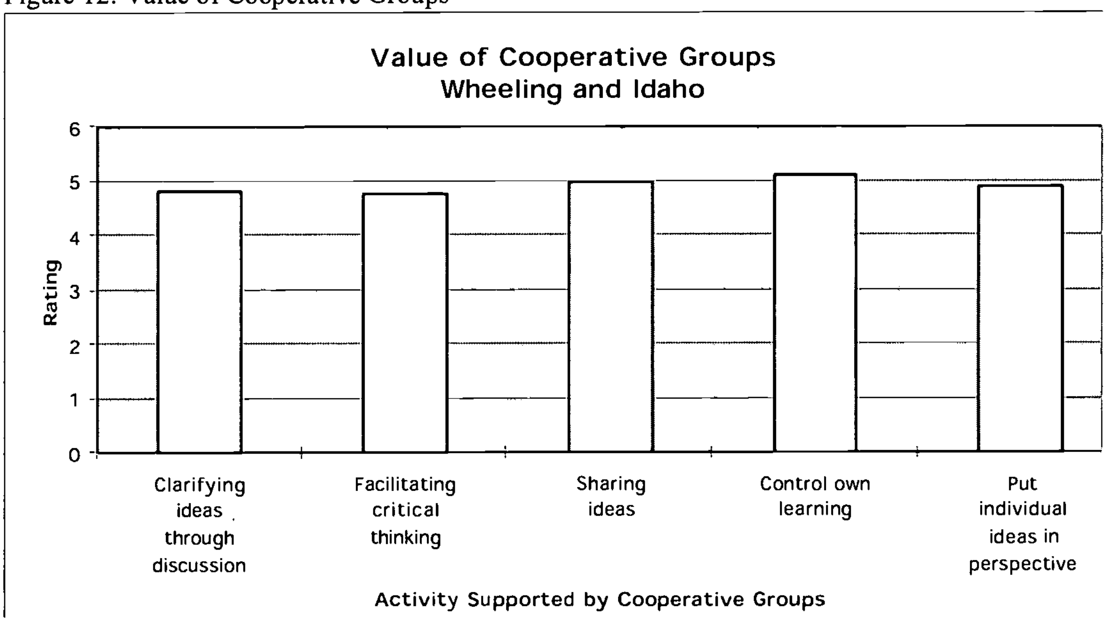
Function of the Cooperative Groups

Additional questions were asked about the use of cooperative groups to try to tease out what made them effective for participants. They were asked to respond to the following statements on a scale of 1-6, with 6=strongly agree:

- Cooperative learning in this course helped clarify ideas and concepts through discussions (both Sphere and Event Groups).
- Cooperative learning in this course facilitated critical thinking.
- Cooperative learning in this course provided opportunities for learners to share information and ideas.
- Cooperative learning in this course provided opportunities for us to take control of our own learning, in a social context.
- Cooperative learning in this course provided validation of individuals' ideas and ways of thinking through conversation, multiple perspectives, and argument.

As Figure 12 shows, the ratings ranged from 4.76 to 5.12, indicating fairly high value for all the functions of cooperative groups. Many participants commented on how nice it was to have so much choice about what to read, when and what and how to contribute to the groups. Those who did not find the cooperative groups as helpful made comments such as: "the groups I was in did not get to the conversation stage" or "I prefer working alone." As one person commented to a mentor, "It's hard to hide in a group in a face-to-face class, and almost impossible in an online course." The typical challenges of uneven participation of group members, lack of direct communication about individual needs, and different pacing needs of participants were dealt with in various ways. One person commented, "I am not sure the labor was evenly divided, but that happens in the classroom too." Experiencing both the power and challenges of collaborative learning were valuable to many people, as one person remarked, "It was important for me to be a student and experience this first hand."

Figure 12: Value of Cooperative Groups



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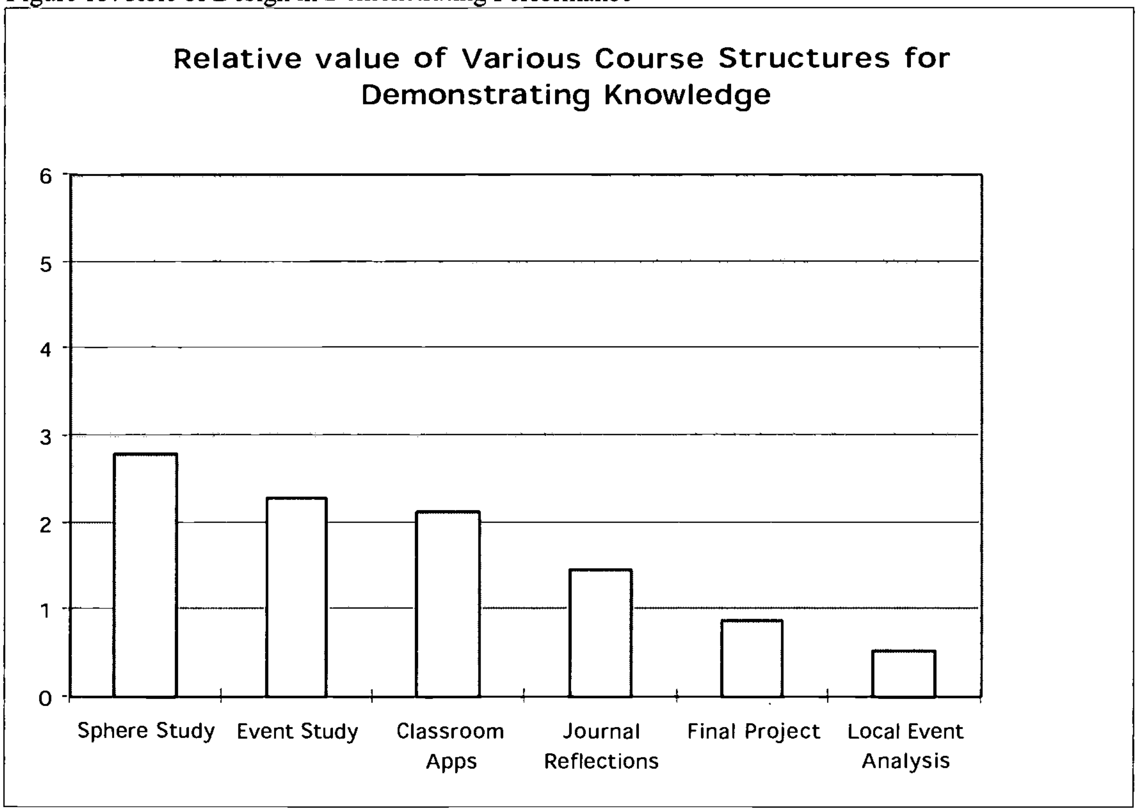
Role of Design in Demonstrating Performance

Course grades were based on individual reflection (journals), use of the ESS ideas and information for teaching (classroom applications) participation (sphere and event study) and synthesis of all the ideas (final product):

• Sphere study	10 points
• Event study	25 points
• Classroom applications	25 points
• Journal reflections	25 points
• Final project	15 points

Figure 13: Role of Design in Demonstrating Performance



Participants were asked to rank from 1-6 (highest) the usefulness of the various structures for showing what they learned. As seen in Figure 10, the relative ranking of the structures was weighed toward the sphere and event study groups. Because of the cooperative learning structure, participants reported gaining insights in the group discussions and learning from a variety of people with different experiences. Many commented on the power of learning about a single sphere, then applying it to an event. By studying each sphere in depth for one of the events, many people felt they improved dramatically in their ability to map the relationships in an ESS diagram.

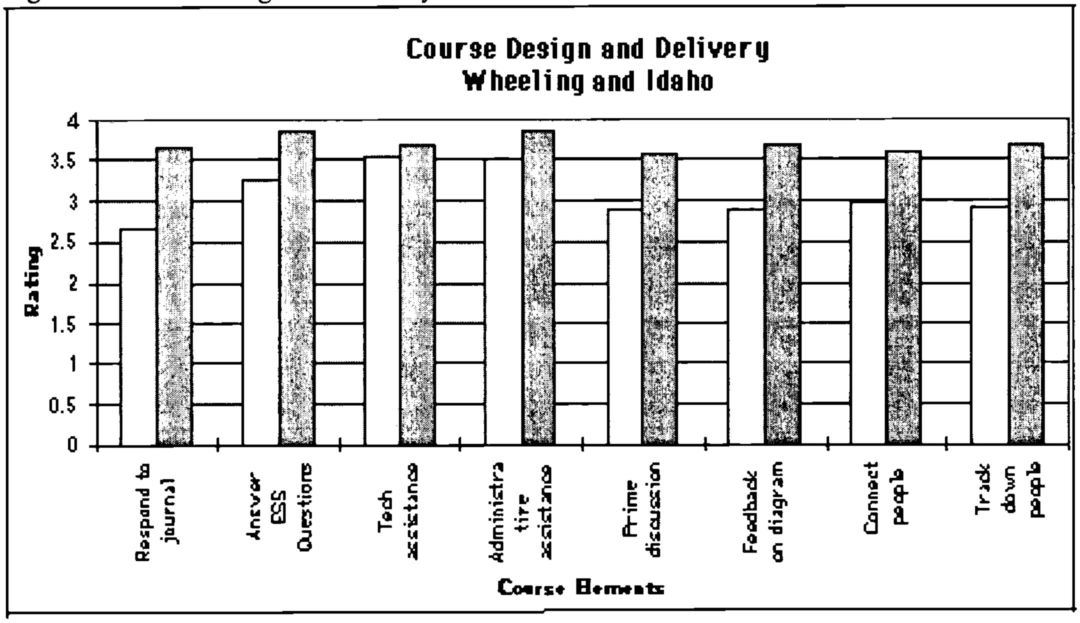
Course Design and Delivery

To examine the flow of ideas, support and feedback in the site design, we asked participants to respond to statements with a rating of frequency in their experience in the course with: (1) Always (2) Often (3) Seldom (4) Never; and a level of importance (1) Very important (2) Sort of important (3) Not very important.

It was important that: and The mentors/facilitators:

- responded to the participants journal entries
- answered questions about ESS content
    - responded to requests for technical assistance
    - responded to requests for administrative assistance, e.g., clarifying assignments, group membership, and location of course content
    - primed group discussion by offering "expert" ideas, hypotheses, or thoughts for our consideration, research, and exploration
    - offered feedback on the earth systems diagrams
    - helped connect people to each other
    - helped track down people who seemed to be "lost" in cyberspace

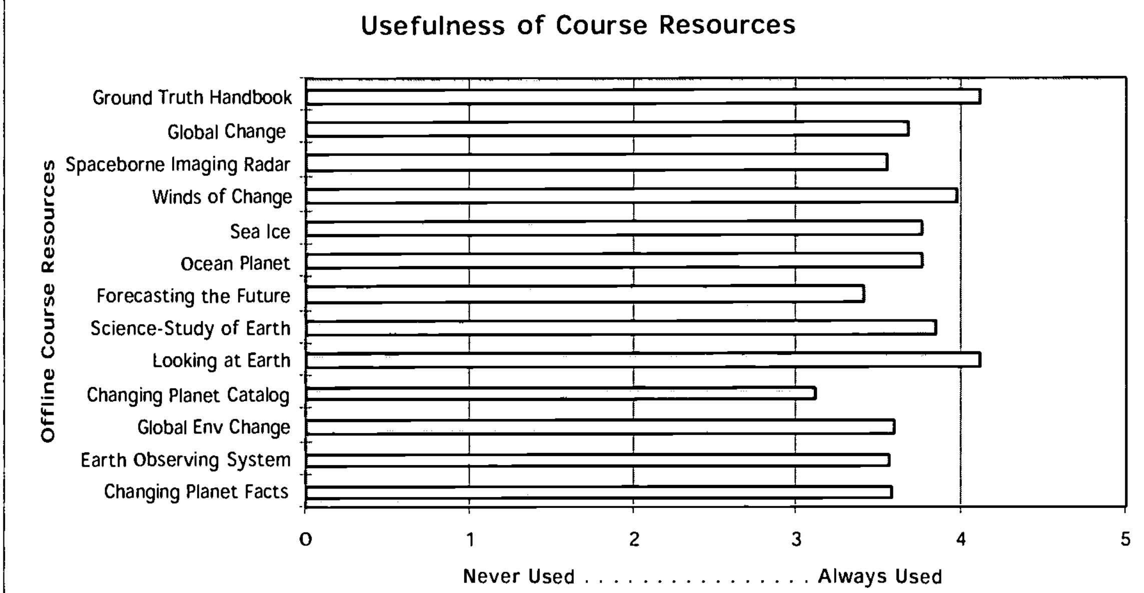
Figure 14: Course Design and Delivery



Usefulness of Course Resources

Participants were asked to rate the course resources sent to them on a scale of 1-5 (never . . . always) in terms of how often they used them. Average ratings ranged from 3.57-4.10, indicating an effective choice of resources for the course.

Figure 15: Usefulness of Course Resources



Educational Importance of the Study

An overriding objective in the development of this online course was to create "reasons" for individuals to engage in the material that could be transferred into the classroom. The population consisted of very busy classroom teachers who needed to be actively involved to compete with their other activities and who could see the practical usefulness of the expectations. Course developers purposely designed the structure so that the course was student-centered and so that participants relied on each other for input. As discussed above, this was accomplished through the jigsaw strategies that made participants depend on each other for essential information in creating the Earth systems diagrams.

As part of this “first run” participants were asking to be forthcoming in their comments throughout the course and in the surveys. Many changes were made along the way to improve communications and better meet the course goals. For example, a participant provided instructions for using of chats for discussions and setting up a web page for a group. Others suggested collapsing the old discussions to make loading quicker. Mentors changed the suggested posting deadlines to give people the whole weekend to work.

Since the course ended, the site has been redesigned with a visual metaphor of the classroom to make the functions of the spaces clearer. The rubrics have been revised and better integrated into the activities. The week-by-week outline has more directions about where (space) and when to participate. One section of this new course is currently being run and others are contemplated as partnerships are formed with teacher inservice programs.

Conclusions

This middle school course was designed to address the needs and style of middle school teachers and their students: high activity, changing groups, ongoing reflection, an opportunity to even out their knowledge of the spheres, and the challenge of doing rigorous analysis of events from an Earth systems science perspective.

While the use of a complex instructional strategy like jigsaw in a non face-to-face environment was considered risky, it was also deemed essential to create the engagement necessary for knowledge-

building. It also provided the perfect opportunity to "walk the talk" about constructivist student-centered strategies (Johnson and Johnson, 1992).

The course evaluations indicate that the design was successful in accomplishing the course goals of increasing the participants' knowledge of Earth systems science and resources, and their use of constructivist and student-centered strategies. While not a goal of the course, comfort with technology and the Internet in particular increased for those participants who had apparently signed up to "get their feet wet" in an environment they see as a strong part of the future of education for themselves and their students.

The importance of place, identity, flow of ideas and information and reflection come alive in a web-based course. The clarity of definition, the scaffolding and the explicitness required caused the team to examine and reexamine both their assumptions and their practice - the goal for the teachers as well as their students. The web provides the opportunity to explore the premise that learning is most powerful in a social context (Vygotsky, 1978). The challenge is to watch ourselves and how our ideas develop through interaction - to become productively self-conscious collaborators in knowledge-building.

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